Having examined thousands (I may say myriads) of these elegant organisms, I am induced to suggest the following arrangement:—

1. *Lagena* (Walker) and *Entosolenia* (Williamson).
2. *Nodosaria* and *Marginulina* (D'Orb.), &c.
3. *Vorticialis* (D'Orb.), *Rotalia* (Lam.), *Lobatula* (Flem.), *Globigerina* (D'Orb.), &c.
4. *Textularia* (Defrance), *Uvigerina* (D'Orb.), &c.
5. *Miliola* (Lam.), *Biloculina* (D'Orb.), &c.

This division must, however, be modified by a more extended and cosmopolitan view of the subject, as I only profess to treat of the British species. To illustrate MacLeay's theory of a quinary and circular arrangement, the case may be put thus.

The first family is connected by the typical genus *Lagena* with the second, and by *Entosolina* with the fifth; the second is united with the third through *Marginulina*; the third with the fourth through *Globigerina*; and the fourth with the last through *Uvigerina*.

Whether these singular and little-known animals are Rhizopodes, or belong to the Amœba, remains yet to be satisfactorily made out.

London, June 18, 1855.

XVI. "Preliminary Research on the Magnetism developed in Iron Bars by Electrical Currents." By J. P. Joule, F.R.S. Received June 21, 1855.

The author had, many years ago, found that the magnetism developed by electro-magnetic coils in bars of upward of $\frac{1}{3}$rd of an inch

diameter, was nearly proportional to the strength of the current and the length of the wire, any alteration, within certain limits, of the diameter of a bar being attended with only trifling effects, so long as the point of saturation was not nearly approached. The Russian philosophers Lenz and Jacobi had, however, stated that the magnetism developed was, *cæteris paribus*, proportional to the diameter of the bar. The discrepancy between the above results is considered by the author to be owing rather to the different circumstances under which the experiments were tried than to any inaccuracies in the experiments themselves. Further, it appeared to him that in any case of induction by electric currents, careful distinction should be made between the several effects, which, compounded together, constitute the total magnetic action. Especially should a distinction be made between the magnetism existing under the inductive influence of the current and that permanently developed so as to remain after the electrical circuit is broken, and therefore the first efforts of the author were directed to ascertain the laws which regulate this permanent effect, or, as he thinks it may be conveniently termed, the *magnetic set*.

In his experiments the magnetism of any bar was ascertained, by placing it vertically with its lower end near a delicately suspended magnetic needle. This was a piece of sewing-needle $\frac{3}{16}$ths of an inch long, furnished with an index of fine drawn glass tube traversing over a graduated circle six inches in diameter. It was suspended by a filament of silk. The tangent of the deflection of the needle was found to be the exact measure of the attraction of a bar. In working with this instrument, it was found that the resistance of the air prevented the needle from swinging even once beyond the point of equilibrium to which it always arrived in less than ten seconds. This resistance of the air, so useful for bringing the needle rapidly to a state of rest, rendered it necessary to keep the entire instrument at a uniform temperature, for the slightest local application of heat produced currents of air within the glass case of sufficient strength to occasion considerable deflections. The circumstance points to the possibility of constructing a new and very sensitive thermometer which might be useful, particularly in experiments on the conduction of heat.

The method of experimenting consisted in observing,—1st. the magnetic attraction of any bar when a current circulated through

its spiral; 2nd. the attraction still subsisting after the circuit was broken; 3rd. the attraction of the other pole of the needle on the reversal of the current; and 4th. the attraction remaining after this reverse current was cut off. The sum of the 1st and 3rd observations gives the total change in the magnetism of a bar by the reversal of the current. The sum of the 2nd and 4th gives the total permanent change of magnetism, or the *magnetic set*.

The experiments were made with iron bars of the several diameters, $\frac{1}{25\cdot6}$, $\frac{1}{17\cdot2}$, $\frac{1}{8}$, $\frac{1}{4}$, $\frac{1}{2}$, and one inch, the length being in each case one yard; and also with iron bars $\frac{1}{8}$, $\frac{1}{4}$, $\frac{1}{2}$ and one inch diameter, of the length of two yards. In all the bars of small diameter up to $\frac{1}{4}$ of an inch, the magnetic set obtained by the use of feeble currents was found to be proportional to the square of the current employed in producing them. This law was found to subsist through a long series of electric intensities; but when the current was increased to a certain amount, the *set*, as observed in the bars of $\frac{1}{25\cdot6}$ and $\frac{1}{17\cdot2}$ of an inch diameter, increased in a much higher ratio, so as to vary, in some instances, with the 4th and 6th powers of the current. The point at which this phenomenon takes place is called the *magnetic breaking point*. A further increase of the current was attended with a rapid decrease of this ratio as the saturation of the bar was approached.

The total change of magnetic condition by reversal of the current, minus the magnetic set, is found to be nearly proportional to the intensity of the current.

Results of exactly similar character were obtained by the use of an electro-magnet, consisting of a bar of hard steel $\frac{1}{4}$ of an inch in diameter and $7\frac{3}{4}$ inches long.

In conclusion, the author points out the striking and instructive analogy which exists between the above phenomena and those of the set of materials as exhibited by Professor Hodgkinson, who, in his admirable researches, has proved that the *set*, or permanent change of figure, in any beam is proportional to the square of the pressure to which it has been exposed.

Communications were read also from the Astronomer Royal and Mr. Macquorn Rankine*.

* Notices of these will appear in the next Number.